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METHOD AND DEVICE FOR LAMINATING SUBSTRATE AND METHOD AND DEVICE FOR MANUFACTURING LIQUID CRYSTAL DISPLAY DEVICE

[Abstract]

PROBLEM TO BE SOLVED: To provide a method for laminating substrates and a device for lamination, in which the pressing force between two substrates can be applied uniformly over the whole substrate, without having to use a precision press mechanism and precision lamination of substrates can be readily performed in a short time, and to provide a method for manufacturing a liquid crystal display device and a device for manufacture.

SOLUTION: Substrates 1, 2 are first mounted on an upper surface plate 15 and a lower surface plate 16, respectively. The upper surface plate 15 and a hollow member 14 are lowered onto the lower surface plate 16, and the pressure in a first space A and in a second space B is reduced. The drive mechanism for the upper

surface plate 15 is released and the pressure in the second space B is gradually increased, so as to press the upper surface plate 15 against the lower surface plate 16 by the pressure difference from the first space A. When the cell gap 12 reaches a prescribed value, a sealing material 4 is irradiated with UV rays from a light guide 13 and hardened.

[Claim(s)]

[Claim 1] A method for laminating a couple of substrates at a predetermined gap and with a seal material engaged therebetween, comprising the steps of:

placing the couple of substrates respectively on two substrate support arranged opposite to each other; and

gradually increasing pressure in a space located opposite to a substrate-mounting side of at least one of the substrate supports with respect to pressure in another space located between the couple of substrates, thereby making the predetermined gap between the couple of substrates.

[Claim 2] A substrate laminating apparatus used for laminating a couple of substrates at a predetermined gap and with a seal material engaged therebetween, comprising:

two substrate supports arranged opposite to each other for placing the couple of substrates respectively thereon,

wherein a first space and a second space are hermetically formed, the first space including a gap formed between the couple of substrates respectively placed on the two substrate supports, the second space including at least a portion of a space

located opposite to a substrate-mounting side of one of the substrate supports, and wherein the pressure of the second space is varied with respect to the pressure of the first space.

[Claim 3] A method for fabricating an LCD device formed by inserting a liquid crystal between a couple of substrates bonded at a predetermined gap with a seal material engaged therebetween, comprising:

a first process of placing the couple of substrates respectively on two substrate supports arranged opposite to each other; and

a second process of gradually increasing pressure of a space located opposite to a substrate-mounting side of at least one of the substrate supports with respect to pressure of another space located between the couple of substrates, thereby making the predetermined gap between the couple of substrates.

[Claim 4] The method of claim 3, wherein the seal material is made of an ultraviolet curable resin, and the seal material is exposed to ultraviolet rays when the predetermined gap is made in the second process.

[Claim 5] The method of claim 3 or 4, further comprising:

a third process of applying a liquid crystal onto one side of the substrate before the first process; and

a fourth process of reducing the pressure of the first and the second space between the first and the second process.

[Claim 6] A substrate laminating apparatus used for laminating a couple of substrates at a predetermined gap and with a seal material engaged therebetween, comprising:

a first substrate support and a second substrate support arranged opposite to each other for placing the couple of substrates respectively thereon,

wherein a first space and a second space are hermetically formed, the first space including a gap formed between the couple of substrates respectively placed on the two substrate supports, the second space including at least a portion of a space located opposite to a substrate-mounting side of one of the substrate supports, and

wherein a pressure of the second space can be varied with respect to a pressure of the first space.

[Claim 7] The apparatus of claim 6, wherein the second substrate support is in contact with the first substrate support while surrounding a region where a substrate is placed, so as to form the first space, further comprising:

a hollow member that is in contact with the first substrate support while covering the first space as well as the second substrate support, so as to form the second

space between the first and the second substrate support; and

elastic members formed on contact portions between the first and the second substrate support as well as between the first substrate support and the hollow member.

[Claim 8] A method for fabricating an LCD device formed by inserting a liquid crystal between a couple of substrates bonded at a predetermined gap with a seal material engaged therebetween, comprising the processes of:

applying a liquid crystal on one side of a substrate;

placing the couple of substrates respectively on two substrate supports arranged opposite to each other; and

reducing pressure of a first space including a gap formed between the couple of substrates respectively placed on the two substrate supports, and pressure of a second space including at least a portion of a space located opposite to a substrate-mounting side of one of the substrate supports, wherein the couple of substrates are bonded with each other by pressing the two substrate supports and thereby pressing the seal material.

[Title of the Invention]

METHOD AND DEVICE FOR LAMINATING SUBSTRATE AND METHOD AND DEVICE FOR MANUFACTURING LIQUID CRYSTAL DISPLAY DEVICE

[Detailed Description of the Invention]

[Field of the Invention]

The present invention relates to a substrate laminating method/apparatus for a liquid crystal display device used in a notebook PC or a display, and a method/apparatus of fabricating a liquid crystal display device.

[Description of the Prior Art]

Fig. 6 shows the configuration of a conventional liquid crystal display device. A liquid crystal is hermetically sealed between two substrates 1, 2 by using a seal material. To maintain a gap (hereinafter, referred to as "cell gap") between the substrates, a spacer 5 is inserted between the substrates and distributed therein. Further, though not shown, a TFT device, a transparent electrode, a color filter, or an alignment film is formed between the two substrates.

With reference to Figs. 6 and 3, a conventional fabrication method for such a liquid crystal display device will be explained. Firstly, after the spacer is formed, the two substrates 1, 2 are bonded, and the seal material 22 is applied around the

gap between the substrates 1, 2 and then is hardened, thereby forming an empty cell 21. The seal material 22 has a passage formed in a portion thereof, which is used as an injection port 23.

This empty cell 21 and a vessel containing a liquid crystal 24 therein are installed in a vacuum chamber 20. The vacuum chamber 20 is vacuumed, air is pumped from the empty cell 21, and the liquid crystal 24 is dispensed. After the vacuum pumping is sufficiently proceeded, the injection port 23 of the empty cell is soaked into the liquid crystal 24, and then the vacuum chamber 24 is returned into the atmospheric pressure. Because of the pressure difference between the inside and the outside of the cell, the liquid crystal 24 is injected into the cell through the injection port 23. After being filled with the liquid crystal, the cell is carried out. Then, the injection port 23 is sealed with an ultraviolet curable resin, such that the sealing of the liquid crystal is completed.

In the fabrication method of the liquid crystal display device shown in Fig. 3, so-called vacuum injection method is used to seal a liquid crystal between the substrates. That is to say, after the empty cell 21 is vacuumed, the injection port 23 is made to contact the liquid crystal and the outside thereof is returned into the atmospheric pressure, such that the liquid crystal can be injected thereinto because of the pressure difference. However, in this method, it is impossible to make a

perfect zero air pressure inside the cell by just vacuuming through the injection port 23, which means that it is impossible to completely remove air therefrom, so that gas molecules are being attached on an inner surface of the cell. Therefore, as the liquid crystal is injected, the inner pressure is increased so that finally the pressure difference disappears and vapor remains therein at the atmospheric pressure. Since the volume of the remaining gas is larger typically in case of a recent wide 15 inch monitor type of liquid crystal display device, it may occur that the remaining gas reaches an image displaying area of the display device.

Further, since the size of the gap between the two substrates has an order of micrometers, it takes very long time to vacuum such a narrow inside of the cell by pumping out through the injection port. Since it takes so long only to fill the cell with the liquid crystal, it needs about 10hours to complete the liquid crystal sealing after starting the cell vacuuming in case of the aforementioned wide 15 inch liquid crystal display device.

To settle the troubles of the vacuum injection method, Japanese Patent Laid-open No. 1988-109413 or Japanese Patent No. 1996-20627 discloses a dropping injection method.

The method of Japanese Patent Laid-open No. 1988-109413 will be explained with reference to Fig. 4. Firstly, as shown in Fig.4a, a seal material 4 and

a spacer 5 are formed on a substrate 2. Then, as shown in Fig.4b, a required amount of liquid crystal 3 is uniformly contained inside the seal material 4 on a reduced atmosphere condition. Then, as shown in Fig. 4c, the other substrate 1 is stacked to contact the seal material 4. Finally, as shown in Fig. 4d, it is pressurized down to remove an empty space inside the cell. The seal is hardened thereafter so as to complete the liquid crystal sealing.

In this dropping injection method, the substrates on which the liquid crystal is dropped are bonded in a reduced atmosphere, so that much time is saved for vacuuming the cell. Further, because the laminating simultaneously completes sealing of the liquid crystal, there is no time required to inject the liquid crystal. Since the amount of supplied liquid crystal is set equal to the inner volume of the cell, the reduced atmosphere condition is needed during the filling of the liquid crystal so as to prevent an empty space inside the cell. Further, because the inside of cell is opened while reducing atmosphere, vapor attached on an inner surface thereof can be effectively removed. Accordingly, it is difficult for gas to remain inside the cell.

Next, the method of Japanese Patent No. 8-20627 will be explained with reference to Fig. 5. Firstly, as shown in Fig. 5a, a liquid crystal 3 is applied on a substrate 2. At this point, to make the liquid crystal 3 simultaneously reach four

sides of a seal material 4, the liquid crystal is supplied in a smaller same shape but a greater thickness than the seal material 4. Then, as shown in Fig. 5b, the other substrate 1 is stacked to the substrate 2. At this point, the substrate 1 should be made contact the seal material 4 before the spreading liquid crystal 3 reaches the seal material 4. Though contacting the seal material 4 at this state, the substrate 1 swells up because of the thicker liquid crystal 3. Then, as shown in Fig. 5c, by loading weight on the substrates 1, 2, the substrate 1 is made platen and the liquid crystal is pressurized to spread so as to remove any empty space inside the cell.

In this method, the liquid crystal would not leak out of the seal material nor prevent the tight attachment between the seal material and the substrates.

With reference to Fig. 6, it will be explained a conventional method of laminating the substrates 1, 2 used in the aforementioned method (vacuum injection method) for fabricating an liquid crystal display device.

Firstly, by using a laminating apparatus, the substrates 1, 2 are aligned and then bonded while pressing the seal material 22 until the gap size therebetween decreases to a few micrometers. At this point, the seal material is hardened by applying ultraviolet rays, such that both substrates 1, 2 are pre-fixed. Then, by using a gap former, it is pressurized and heated until the gap size between the bonded substrates 1, 2 becomes a particle diameter of the spacer, such that a main

hardening of the seal material is performed using a thermosetting characteristic thereof.

[Problems to be Solved by the Invention]

In the above described liquid crystal display device, the gap size between the two substrates has an order of micrometers, and it becomes more and more thin. Therefore, it is very important in the method to align the substrates parallel to each other without skew during laminating.

In the liquid crystal display device fabrication method using the vacuum injection, since only a mechanical pressing is engaged, a large and expensive equipment is needed to precisely control the parallel relationship between both substrates.

Further, in this method, the pressing of two substrates should be performed both in the process of aligning and pre-fixing and in the process of pressing until the gap size becomes a particle diameter of the spacer. Since, however, there is a great difference in pressure between the two processes, different equipments should be respectively used, and the fabrication time and cost are increased.

Further, also in the dropping injection method, since only a mechanical pressing is engaged, a large and expensive equipment is needed to precisely control the parallel relationship between both substrates.

The present invention is to settle the aforementioned troubles, thereby providing a substrate laminating method/apparatus and an liquid crystal display fabrication method/apparatus by which two substrates are precisely bonded and the productivity can be enhanced.

[Means for Solving the Problem]

In accordance with a first embodiment of the present invention, there is provided a method for laminating a couple of substrates at a predetermined gap and with a seal material engaged therebetween, comprising the steps of: placing the couple of substrates respectively on two substrate supports arranged opposite to each other; and gradually increasing pressure in a space located opposite to a substrate-mounting side of at least one of the substrate supports with respect to pressure in another space located between the couple of substrates, thereby making the predetermined gap between the couple of substrates.

In accordance with a second embodiment of the present invention, there is provided a substrate laminating apparatus used for laminating a couple of substrates at a predetermined gap and with a seal material engaged therebetween, comprising: two substrate supports arranged opposite to each other for placing the couple of substrates respectively thereon, wherein a first space and a second space are hermetically formed, the first space including a gap formed between the

couple of substrates respectively placed on the two substrate supports, the second space including at least a portion of a space located opposite to a substrate-mounting side of one of the substrate supports, and wherein pressure of the second space can be varied with respect to pressure of the first space.

In accordance with a third embodiment of the present invention, there is provided a method for fabricating an LCD device formed by inserting a liquid crystal between a couple of substrates bonded at a predetermined gap with a seal material engaged therebetween, comprising: a first process of placing the couple of substrates respectively on two substrate supports arranged opposite to each other; and a second process of gradually increasing pressure of a space located opposite to a substrate-mounting side of at least one of the substrate supports with respect to pressure of another space located between the couple of substrates, thereby making the predetermined gap between the couple of substrates.

In accordance with a fourth embodiment of the present invention, there is provided a method of the third embodiment in which the seal material is made of an ultraviolet curable resin, and the seal material is exposed to ultraviolet rays when the predetermined gap is made in the second process.

In accordance with a fourth embodiment of the present invention, there is provided a method of the third and the fourth embodiments which comprises a third

process of applying a liquid crystal onto one side of the substrate before the first process; and a fourth process of reducing the pressure of the first and the second space between the first and the second process.

In accordance with a fourth embodiment of the present invention, there is provided a substrate laminating apparatus used for laminating a couple of substrates at a predetermined gap and with a seal material engaged therebetween, which comprises: a first substrate support and a second substrate support arranged opposite to each other for placing the couple of substrates respectively thereon, wherein a first space and a second space are hermetically formed, the first space including a gap formed between the couple of substrates respectively placed on the two substrate supports, the second space including at least a portion of a space located opposite to a substrate-mounting side of one of the substrate supports, and wherein a pressure of the second space can be varied with respect to a pressure of the first space.

In accordance with a fourth embodiment of the present invention, there is provided an apparatus of the sixth embodiment in which the second substrate support contacts the first substrate support while surrounding a region where a substrate is placed, so as to form the first space, the apparatus further comprising: a hollow member that contacts the first substrate support while covering the first

space as well as the second substrate support, so as to form the second space between the first and the second substrate support; and elastic members formed on contact portions between the first and the second substrate support as well as between the first substrate support and the hollow member.

In accordance with a fourth embodiment of the present invention, there is provided a method for fabricating an LCD device formed by inserting a liquid crystal between a couple of substrates bonded at a predetermined gap with a seal material engaged therebetween, comprising the processes of: applying a liquid crystal on one side of a substrate; placing the couple of substrates respectively on two substrate supports arranged opposite to each other; and reducing pressure of a first space including a gap formed between the couple of substrates respectively placed on the two substrate supports, and pressure of a second space including at least a portion of a space located opposite to a substrate-mounting side of one of the substrate supports, wherein the couple of substrates are bonded with each other by pressing the two substrate supports and thereby pressing the seal material.

[Embodiment of the Invention]

(First Embodiment)

Hereinafter, the present invention will be described with respect to preferred

embodiments of a substrate laminating method, a substrate laminating apparatus, an LCD fabrication method, and an LCD fabrication apparatus method and an apparatus of joining substrates with reference to Fig. 1. In this regard, the following is a description made to a case of fabricating the LCD using a dropping injection method, however, it is understood that the present invention is not limited thereto.

First of all, the following is a description for a manufacturing apparatus used in a preferred embodiment of the present invention.

The apparatus comprises a lower plate 16 (a first substrate support) for loading a substrate, an upper plate 15 (a second subtrate support) for loading another substrate, and a hollow member 14 formed as covering the upper plate 15 with a distance therebetween. The upper plate 15 and the hollow member are movable in up and down directions with respect to the lower plate 16 by driving mechanisms (not shown), respectively.

The upper plate 15 has an upright part around a plain part on which the substrate is mounted and an elastic member 15a is provided at a tip end of the upright prtion. And, when the upper plate 15 is pressurized against the lower plate 16, the elastic member 15a is contacted with the lower plate 16, a space between the upper plate 15 and the lower plate 16 (a first space) is made airtight. Further, the upper plate 15 is movable up and down as described above, and the position

thereof can be precisely controlled along a surface direction of the substrate.

The hollow member 14 includes an upright part enclosing the upper plate 15 and the first space and a plain part, and an elastic member 14b is installed at a tip end of the upright part. When the hollow member 14 is pressurized against the lower plate 16, the elastic member 14b is contacted with the lower plate 16, and a space between the elastic member 14b and the upper plate 15 (a second space) is made airtight.

The lower plate 16 and the upper plate 14 are provided with openings 16a and 14a to vacuum the first and the second spaces, respectively.

The upper plate 15 is further provided with a cell-thickness measuring device 11 to measure the cell gap 12 and a light guide 13 to transmit light therethrough.

Hereinafter, it will be describled the method of laminating substrates, and a method of making LCD device using the fabricating apparatus.

(Step 1) Referring to Fig. 1a, firstly, in a first substrate 1, a liquid crystal, which had been decompressed and then experianced a removal of bobbles, is applied on a rectangular film having a thickness of (5㎛) defined as same thickness as the liquid crystal layer at the time of the completion of a substrate sealing. And then, a spacer 5 is distributed and a seal material 4 is applied to another substrate

2 (a third process).

A line is drawn with an ultraviolet curable resin to have a width of 0.4 mm and a thickness 25μm within a rectangular area spaced by 0.5 mm from an apperaence of the liquid crystal to be applied in the seal material 4 by uising a dispenser. The seal material 4 does not disturb the appliance of the liquid crystal 3 since the seal material 4 is installed at the substrate 2 without having the liquid crystal applied thereron.

(Step 2) Referring to Fig. 1b, a pair of the substrates 1, 2 are mounted onto the upper and the lower plates 15, 16 so that the surface having the liquid crystal applied thereon is opposited to the surface having the seal material and the spacer installed thereon (a first process).

(Step 3) Referring to Fig. 1c, the hollow member 14 and the upper plate 15 are lowered to press the lower plate 16 with the elastic members 15a, 14b positioned therebetween and then to maintain this state. And, air is pumped from the first space sealed by the upper plate 15 and the lower plate 16 through the opening formed in the lower plate 16 using a first vacuum pump (not shown), to thereby depress the first space below 1 Torr. Simultaneously, air is pumped from the second space sealed by the hollow member 14 and the lower plate 16 through the opening formed in the lhollow member using a second vacuum pump (not

shown), to thereby decompress the second space below 20 Torr (a forth process). Accordingly, the gas disloved in the liquid crystal 3 at the time of the appliance thereof and the gas molecules absorbed in the surfaces of the first and the second substreates 1,2 are removed by virture of the decompression.

Moreover, as described above, a reason of the decompression of the second space is that a sudden high pressure produced from the upper plate 15 may have an adverse effect on the lower plate 16 in case where the first space is decompressed alone, which causes a breakage and a misalignment of the substrates, as will be described hereinafter.

(Step 4) The elastic members 15a, 14b are pressurized and the distance between the substrates is approached to 0.5 mm so that both substrates are aligned in a horizontal surface. In this regard, since a space between the substrate 1 and the seal material 4 is formed, there does not occur that the seal material 4 is deviated or contacted with the liquid crystal owing to the alignment. And, such an alighment is carried out within the deformable range of the elastic members 15a, 14b.

(Step 5) Referring to Fig. 1d, while measuring the cell gap 12 with the cell-thickness measuring device 11 in a portion having the liquid crystal therein, the driver for moving up and down directions is disengaged from the upper plate 15

and the upper plate is pressurized against the lower plate 16 with the weight itself of the upper plate and the pressure difference between the first and the second spaces.

(Step 6) And then, as air is provided through the opening 14a, a pressure in the second space is gradually increased accordingly (a second process). Therefore, two substrates 1, 2 are slowly pressurized facing each other. At this time, the elastic member 15a is pressured, but is retained in an elastic arrea, so that the seal material 4 between the substrates 1, 2 is pressed, to thereby bond them. The seal material 4 is pressed to be from 25㎛ to 5㎛ to thereby expand a line width from 0. 4 mm to 2 mm.

The inner side of the seal material 4 before being pressurized has a distance 0.5 mm from the liquid crystal 3. The seal material 4 is expanded in and out to fill in the space between the liquid crystal 3 and the seal material 4. As the seal material is outwardly expanded as the liquid crystal if the liquid crystal 3 is, if the expansion is fall in this extent, it is possible to remedy the position difference induced by the ununiformity of the amount of the liquid crystals and the alignment of the upper and the lower substrates without being pushing and flowing the bubble and the seal material.

Although the liquid crystal 3 is applied by a thickness defined by the cell

gap, the liquid crystal would not closely attached to the entire surface of the substrate without providing the pressurization thereto owing to the resistence of the seal material and the spacer. Therefore, if the pressurization is applied slowly while actually measuring the cell gap, it is possible to devoid the cell gap difference caused by an excessive pressure or a lack of the pressurization.

In a vacuum injection method, the liquid crystal does not exist at the time of laminating the empty cells, and an air layer of several μm can not be precisely measured. And, because the vacuum injection method does not measure the cell thickness, but control the cell gap while experientially changing the injection time, the ununiformity of individual cells entails a cell gap error. However, according to the dropping injection of the present invention, it is possible to devoid the cell gap error as described above.

A device to measure an obstacle used to measure the cell gap after the liquid crystal injection is applicable to the cell-thickness measuring device.

(Step 7) When it is satisfied that the layer of the liquid crystal has a predetermined thickness, ultraviolet rays are irradated to the seal material 4 to cure it. The ultraviolet rays are irradated only to the seal material from the rear surface of the substrate through the light guide 13, without being radiated to the liquid crystal 3.

(Step 8) First of all, the decompression of the first space is removed to return into an atomospheric pressure, the second space is leaked to return into an atomospheric pressure, the upper plate 15 and the hollow member 14 are driven upward to pull out the bonded substrates, thereby completing the sealing of the substrates.

Further, the ultraviolet curable resin used in the seal material is not completely hardened by the ultraviolet rays for a short time. Thus the bonded substrates, which have been bonded by the above sequences, is placed at a UV furnace, the portion of the liquid crystal is irradiated by the ultraviolet rays for several minutes to several tens minutes using a mask to completely harden it. Further, in order to speed up the hardening, it is preferred to heat the bonded substrated at about 10°C to 50°C over a room temperature. However, if overheating is made, there may possibly occur a position difference between the two substrates due to a thermal expantion or a bent of the substrates to separate the substrates. Therefore, it is necessary to heat the substrates in the range without incurring the above problem.

As described above, according to the embodiment of the present invention, the power exerted by the pressure difference is pressurized to the substrates. Therefore, it is possible to bond the substrates by evenly applying the pressure to

the substrates with a simple arrangement and to prevent the unevenness of the cell thickness. Because the power to be applied can be slowly and highly changed by slowly changing the pressure difference, it is possible to determine the gap between the substrates using only any one of the pressurization apparatuses without destoring the substrates, which results an improvement of a productivity as well as a reduction of manufacturing cost.

(Second Embodiment)

Hereinafter, another embodiment of the present invention will be described with reference to Fig. 1. In this regard, the description of the second embodiment is made to a case of fabricating the LCD using a dropping injection method, however, it is understood that the present invention is not limited thereto.

First of all, the following is a description for a manufacturing apparatus used in a preferred embodiment of the present invention.

The apparatus comprises a lower plate (a first substrate support) 16 for loading a substrate, an upper plate (a second subtrate support) 45 for loading the other substrate, and a hollow member 44 formed as covering the upper plate 45 with a distance therebetween. The upper plate 45 and the hollow member 44 are movable in up and down directions with respect to the lower plate 16 by driving mechanisms (not shown), respectively.

The upper plate 45 has an upright part around a plain part on which the substrate is mounted and a triangular protrusion 45a in its cross section is installed at a tip end of the upright prtion. And, the upper plate 15 is movable up and down as described above, and the position thereof can be precisely controlled along a surface direction of the substrate.

The hollow member 44 includes an upright part enclosing the upper plate 45 and a plain part, and a triangular protrusion 44b in its cross section is installed at a tip end of the upright part.

The lower plate 46 has elastic members 46a, 46b at positions corresponding to the triangular protrusion 45a, 46b. And, when the upper plate 45 is pressurized against the lower plate 16 (that is, the protrusion 45a is pressurized against the elastic member 46b), a space between the upper plate 45 and the lower plate 416 (a first space) is made airtight. Further, when the hollow member 44 is pressurized against the lower plate 46 (that is, the protrusion 44b is pressurized against the elastic member 46b), a space between the hollow member 44 and the upper plate 45 (a second space) is made airtight.

The lower plate 16 and the upper plate 14 are provided with openings 46a and 44a to vacuum the first and the second spaces, respectively.

The upper plate 45 is further provided with a cell-thickness measuring

device 11 to measure the cell gap 32 as similar as in Fig. 1d, and a light guide 33 to transmit light therethrough.

Hereinafter, it will be describled the method of laminating substrates, and a method of making LCD device using the fabricating apparatus.

(Step 11) Referring to Fig. 2a, firstly, in a first substrate 1, a liquid crystal, which had been decompressed and then experianced a removal of bobbles, is applied on a rectangular film having a thickness of (5μm) defined as same thickness as the liquid crystal layer at the time of the completion of a substrate sealing. And then, a spacer 35 is distributed and a seal material 34 is applied to another substrate 2 (a third process).

A line is drawn with an ultraviolet curable resin to have a width of 0.4 mm and a thickness 25μm within a rectangular area spaced by 0.5 mm from an apperaence of the liquid crystal to be applied in the seal material 34 by uising a dispenser. The seal material 34 does not disturb the appliance of the liquid crystal 3 since the seal material 34 is installed at the substrate 2 without having the liquid crystal applied thereron.

(Step 12) Referring to Fig. 2b, a pair of the substrates 1, 2 are mounted onto the upper and the lower plates 45, 46 so that the surface having the liquid crystal applied thereon is opposited to the surface having the seal material 34 and

the spacer 35 installed thereon (a first process).

(Step 13) Referring to Fig. 2c, the hollow member 44 and the upper plate 45 are lowered to pressurize the protrusions 45a, 44b on the elastic member 46b of the lower plate 16 and then to maintain this state. And, air is pumped from the first space sealed by the upper plate 45 and the lower plate 46 through the opening 46a formed in the lower plate 46 using a first vacuum pump (not shown), to thereby depress the first space below 1 Torr. Simultaneously, air is pumped from the second space sealed by the hollow member 44 and the lower plate 46 through the opening 44a formed in the hollow member 14 using a second vacuum pump (not shown), to thereby depress the second space below 20 Torr (a forth process). Accordingly, the gas disloved in the liquid crystal 3 at the time of the appliance thereof and the gas molecules absorbed in the surfaces of the first and the second substreates 1, 2 are removed by virture of the decompression.

(Step 14) The elastic members 46b are pressurized and the distance between the substrates 1, 2 is approached to 0.5 mm so that both substrates are aligned in a horizontal surface. In this regard, since a space between the substrate 1 and the seal material 4 is formed, there does not occur that the seal material 4 is deviated or contacted with the liquid crystal 3 owing to the alignment. And, such an alighment is carried out within the deformable range of the elastic member 46b.

(Step 15) Referring to Fig. 2d, while measuring the cell gap 32 using the cell-thickness measuring device 31 in a portion having the liquid crystal therein, the driver for moving up and down directions is disengaged from the upper plate 45, and the upper plate 45 is pressurized against the lower plate 46 with the weight itself of the upper plate and the pressure difference between the first and the second spaces (a second process).

(Step 16) And then, as air is provided through the opening 44a, a pressure in the second space is gradually increased accordingly. Therefore, two substrates 1, 2 are slowly pressurized facing each other. At this time, the elastic member 46b is pressurized, but is retained in an elastic arrea, so that the seal material 34 between the substrates 1, 2 is pressered, to thereby bond them. The seal material 4 is pressed to be from 25µm to 5µm to thereby expand a line width from 0. 4 mm to 2 mm.

The inner side of the seal material 34 before being pressurized has a distance 0.5 mm from the liquid crystal 3. The seal material 34 is expanded in and out to fill in the space between the liquid crystal and the seal material. As the seal material is outwardly expanded as the liquid crystal if the liquid crystal 3 is, if the expansion is fall in this extent, it is possible to remedy the position difference induced by the ununiformity of the amount of the liquid crystals and the alignment

of the upper and the lower substrates without being pushing and flowing the bubble and the seal material.

Although the liquid crystal 3 is applied by a thickness defined by the cell gap, the liquid crystal would not closely attached to the entire surface of the substrate without providing the pressurization thereto owing to the resistence of the seal material 34 and the spacer 5. Therefore, as the pressurization is applied slowly while actually measuring the cell gap, it is possible to devoid the cell gap error caused by an excessive pressure or a lack of the pressurization.

(Step 17) The driver of the upper plate 45 is engaged, to settle the up and down operations of the upper plate. And, a pressure in the second space is increased. At this time, if there exists a decompression space between the seal mmaterial 34 and the liquid crystal 33, the seal material 34 is continued to flow until filling in the decompression space because the seal material 34 is liquid if it does not hardened upto present.

(Step 18) When it is satisfied that the layer of the liquid crystal has a predetermined thickness, ultraviolet rays are irradated to the seal material 34 to cure it. The ultraviolet rays are irradated only to the seal material from the rear surface of the substrate through the light guide 33, without being radiated to the liquid crystal 3.

(Step 19) First of all, the decompression of the first space is removed to return into an atomospheric pressure, the second space is leaked to return into an atomospheric pressure, the upper plate 45 and the hollow member 44 are driven upward to pull out the bonded substrates, thereby completing the sealing of the substrates.

Further, the ultraviolet curable resin used in the seal material is not completely hardened by the ultraviolet rays for a short time. Thus the bonded substrates, which have been bonded by the above sequences, is placed at a UV furnace, the portion of the liquid crystal is irradiated by the ultraviolet rays for several minutes to several tens minutes using a mask to completely harden it. Further, in order to speed up the hardening, it is preferred to heat the bonded substrated at about 10°C to 50°C over a room temperature. However, if overheating is made, there may possibly occur a position difference between the two substrates due to a thermal expantion or a bent of the substrates to separate the substrates. Therefore, it is necessary to heat the substrates in the range without incurring the above problem.

As described above, according to the embodiment of the present invention, the power exerted by the pressure difference is pressurized to the substrates. Therefore, it is possible to bond the substrates by evenly applying the pressure to

the substrates with a simple arrangement and to prevent the unevenness of the cell thickness. Because the power to be applied can be slowly and highly changed by slowly changing the pressure difference, it is possible to determine the gap between the substrates using only any one of the pressurization apparatuses without destoring the substrates, which results an improvement of a productivity as well as a reduction of manufacturing cost.

In addition, in the dropping injection method, when the first space used for removing bubbles is decompressed, the second space is also decompressed. Accordingly, none of sudden pressure is applied to the space between the substrates; it is possible to prevent the damage of the substrates. Moreover, it is possible to determine the gap between the substrates.

The embodiments of the present invention as described above are illustrated with respect to the substrate laminating method and apparatus; and an LCD fabrication method and apparatus, and various modifications are possible. Following is a description of the examples of the modification.

(1) The substrate laminating method and apparatus of the present invention is applicable to the joining of substrates used in LCD device as well as the joining of substrates used in plasma display or the like and the other application.

(2) The substrate laminating method and apparatus are not limited to

comply the dropping injection method and are applicable to the vacuum injection method.

(3) There is no need to form the first and the second space as in the first and the second embodiments of the present invention. It is preferred to form the first space by hermetically sealing any space including the space between substrates using any appropriate shape, and to form the second space by sealing any space including at least a portion oppositing to a substrate holding part in the subtrate holding member (either the upper plate or the lower plate) using any appropriate shape.

(4) The method described in the first and the second embodiments can be modified with a design and an application. For example, the embodiment described that the seal material and liquid crystal film are installed in separate substrates, but it is possible to install same substrate. Further, it is preferred that the pressure of the first and the second spaces are set so that the pressure to the substrates is appropriate, and the timings to the decompression and the pressurization are not constrained to the embodiments.

[Effect of the Invention]

According to the substrate laminating method and apparatus, it is possible to uniformly apply the pressurization to the substrates without using a precise

pressurization device, to thereby achieve an ease joining and a shorthened time of the substrate.

According to the substrate laminating method and apparatus, it is possible to uniformly apply the pressurization to the substrates without using a precise pressurization device, to thereby achieve an improvement of productivity as well as a reduction of manufacturing cost of manufacturing the liquid crystal display device, which is free from the ununiform cell thickness and the bubble leaked from the liquid crystal.

Further, according to the manufacturing method and apparatus of the liquid crystal display device, because the second space is also decompressed when the first space used for removing bubbles is decompressed, there is none of sudden pressure to be applied to the space between the substrates; further, it is possible to prevent the damage of the substrates. Moreover, it is possible to determine the gap between the substrates.

[Description of Drawings]

Fig. 1 shows a method of fabricating a liquid crystal display device according to a preferred embodiment of the present invention;

Fig. 2 illustrates a method of fabricating a liquid crystal display device according to another preferred embodiment of the present invention;

Fig. 3 describes a diagram illustrating a conventional prior art vacuum injection method;

Fig. 4 describes a diagram illustrating a conventional dropping injection method;

Fig. 5 describes a diagram illustrating another conventional vacuum injection method; and

Fig. 6 depicts a structure of a typical liquid crystal display device.

[Meaning of numerical symbols in the drawings]

1, 2 : substrate	3 : liquid crystal
4, 34 : seal material	5 : spacer
11, 31 : cell-thickness measurement device	12, 32 : cell gap

13, 33 : light guide

14, 44 : hollow member

14a, 44a : opening

14b : elastic member

15, 45 : upper plate

15a, 45a : elastic member

16, 46 : lower plate

16a, 46a : opening

44b, 45a : protrusion

46b : elastic member